Swash Zone Dynamics: Modeling and Data Analysis

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LONG-TERM GOALS

The goals of the project are to develop better understanding and predictive capability for non-linear time-dependent dynamics in the swash zone. Although sophisticated models for simulating swash hydrodynamic processes are available (a Navier-Stokes based swash model that implements the Volume of Fluid (VOF) method is being adapted under separate funding), detailed measurements within this dynamic region are needed to develop and validate models describing coupled fluid-sediment transport.

OBJECTIVES

This project is designed to collect and analyze both field and laboratory measurements of swash zone processes for comparison with the numerical VOF model results. Of particular interest is quantification of time-dependent flow velocities at high resolution over a large spatial area. Non-linear interactions may be extremely important in how shear stresses resulting from such flows mobilize and transport foreshore sediments. By observing the flow structure and resulting sediment response at high resolution under constrained forcing conditions, we seek to develop a shear stress formulation applicable to field conditions. The numerical model simulations will be used to expand our understanding at scales that can be predicted but not measured.

APPROACH

Swash zone measurements are being obtained by the Naval Research Laboratory at the Large-Scale Sediment Transport Facility (LSTF) at the Waterways Experiment Station in Vicksburg, MS. The LSTF is comprised of a 30-m by 50-m basin with waves generated using a series of four synchronized unidirectional spectral wave generators. In addition, longshore currents can be simulated using twenty independent vertical turbine pumps. A cross-shore array of wave gauges, acoustic Doppler velocimeters, arrays of fiber-optic backscatter sensors, and a rapidly-sampling beach profiler are mounted on a mobile, programmable instrumentation bridge that spans the basin. A series of twenty sediment traps are located in flow channels at the downstream end of the facility and the weight of sand that accumulates in each trap is recorded in real time. Supplemental instrumentation installed by NRL allowed measurement of water level elevation, alongshore currents and cross-shore currents along a series of cross-shore transects. We will used video imaging techniques, such as particle image velocimetry, to record swash flow variation in the alongshore (see Holland et al., 1997; Holland et al., 2001).

WORK COMPLETED

Instrumentation was installed in the facility in May 2001 and three data sets have been obtained. The first set of conditions (sampled May 31 2001) comprised a simple wave case to verify instrument performance and the second set (sampled July 10 2001) was of 16 cm waves at 3 second period. Irregular waves were sampled June 19 2002. The 6 m domain covered in detail by the in situ and video-based instrumentation is consistent with the domain being modeled by Dr. Slinn.

RESULTS

The main goal of the original test was to determine if the numerical VOF model gave sensible predictions under simplified laboratory conditions. The in-situ observations obtained by NRL (figure 1) show a very good comparison between sampled and predicted sea surface elevations. Velocity comparisons were also similar showing a consistent change in the onshore velocity component from offshore to onshore. No strong vertical gradients were observed. These preliminary comparisons suggest that the numerical model (using an approximately 5 mm vertical grid spacing) will serve as a useful descriptor for swash zone hydrodynamic processees and related sediment transport.

IMPACT/APPLICATIONS

This research is critical to the understanding of swash zone sediment transport processes and will greatly aid in the development of coupled models describing beach profile change and coastal erosion.

TRANSITIONS

These data are being made available to the investigators at the USACE LSTF for quantifying swash processes within their facility under various wave conditions.

RELATED PROJECTS

The most closely related project is the numerical simulation model for swash zone processes being developed by Dr. Donald Slinn at the University of Florida. NRL and UF are working collaboratively to develop and validate a high-resolution model describing swash zone processes.

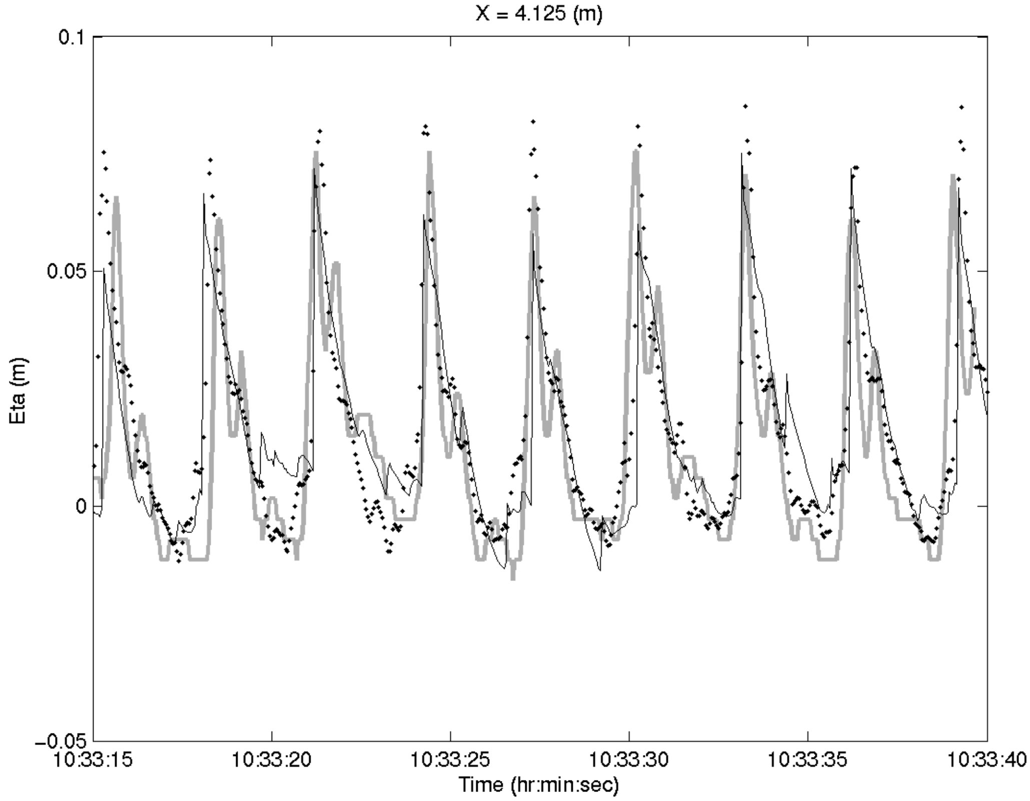

Figure 1 Sea surface comparison between ADV data (dots), RIPPLE (gray), and RBREAK2 (black) in the inner surf zone.

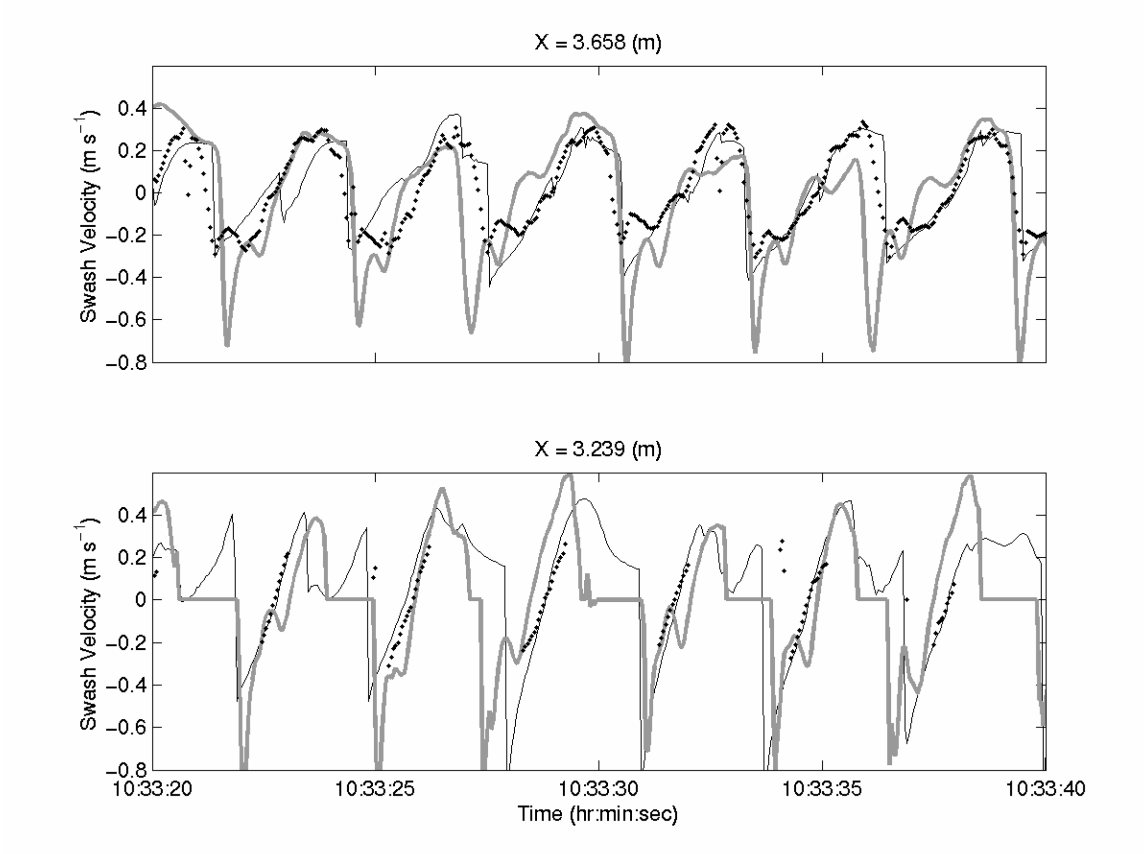

Figure 2 Velocity comparison for ADV (dotted), RBREAK2 (depth averaged; black) and RIPPLE (gray). Upper panel is for outer swash zone and lower panel for middle swash zone. Negative velocities are onshore, positive velocities offshore.

REFERENCES

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PUBLICATIONS

Puleo, J.A., Holland, K.T., Slinn, D.N., Smith, E. and Webb, B.M., 2001. Numerical modeling of swash zone hydrodynamics, Proceedings of the 28th International Conference on Coastal Engineering. ASCE, Cardiff, UK.